Experiment Thrust

Developing Theoretical Concepts for Experimentation

Fiore, S. M. & Salas, E. (2007). Developing Theoretical Concepts for Experimentation. *Presentation to the Office of Naval Research Collaboration and Knowledge Interoperability Program,* Arlington, VA, August 9th, 2007.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2007	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Experiment Thrust	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Office of Naval Research**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**14**	

Theoretical Concepts for Experimentation

Developing Theoretical Concepts for Experimentation

- Parallel approach to Experimentation Thrust
  - Overall focus on augmenting and developing macrocognition concepts
- **A) *Asking how can we enrich understanding of foundational collaboration concepts through empirical studies?***
- **B) *Testing macrocognition concepts through refined measurement techniques***

- **A) Presenting overarching concepts for macrocognition experiments**
  - *Understanding Problem Space and Impact of Task*
- **B) Discussing metrics experimentation to support more diagnostic and construct valid understanding of macrocognition**

Theoretical Concepts for Experimentation

Overarching Research Questions for SUMMIT Experimentation

- **How do task factors alter macrocognitive processes?**
  - *How do changes to task complexity (e.g., low versus high integrative complexity) impact macrocognitive stages and/or processes?*
  - *How do changes to task structure (e.g., ill-structured versus well-structured) impact the manner in which teams collaborate as they work through macrocognitive stages and/or processes?*
- How does distributed interaction influence differing elements of collaboration?
  - *What happens to information processing within and across teams when members are not all co-located?*
  - *How do changes to the task interact with distributed interaction?*
- What is the impact of agent-based team members?
  - *How does inclusion of agents supporting certain macrocognitive processes impact overall stages and/or processes?*
  - *Do task variations interact with inclusion of agents in their impact on macrocognition?*
- **Can we triangulate on macrocognitive processes through improved measures?**
  - *What measures provide the most diagnostic utility as to assessing macrocognition across the stages of collaborative problem solving?*

Theoretical Concepts for Experimentation

Macrocognition and Experimentation with Task Variation

- **Background**
  - CKI program now looking at macrocognition in varied tasks
- **SUMMIT Goal**
  - Assess how variation of theoretically important factors, within a given testbed, alters macrocognition
- **Rationale**
  - *Practical Significance*
    - Research across variety of situational factors would support understanding and improving operational performance
  - *Theoretical Significance*
    - Research on macrocognition would benefit from further integration of cognitive science concepts
    - *Task classifications would clarify influence of task structure and complexity to help better understand macrocognition*

Theoretical Concepts for Experimentation

Developing Theoretical Concepts for Experimentation

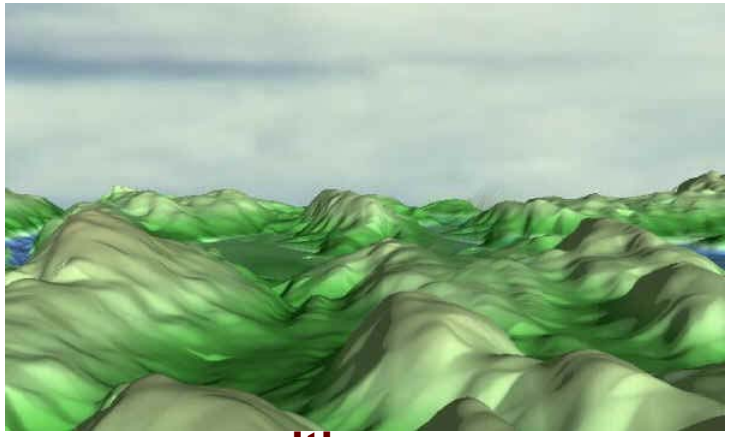
Macrocognition – *Problem Space and Influence of Task*

- Understanding problem space theory in context of macrocognition (Newell & Simon, 1972)
  - the mental space in which the problem solver must encode problem elements -- defining goals, rules and other aspects of the situation... [that] represent:
    - the initial situation presented
    - the desired goal situation
    - various intermediate states, imagined or experienced

Theoretical Concepts for Experimentation

Macrocognition - *Problem Space and Influence of Task*

- Reifying Problem Space Concept through Operationalization of Task Variability
  - *Question is how do task factors alter problem space*
    - The task defines the "topology" of the problem space
      - *Dictates paths through the problem space available to the problem solver*
      - *Some successfully lead to solution*
      - *Collaborative process determines path choice*



- **Experimentation will explore how this alters macrocognitive processes**
  - ***Overarching Hypothesis***
    - ***Differential impact of task manipulations on subcomponents of macrocognition***
    - ***For example, there will changes to quantity and quality of knowledge building when task is more ill-structured?***

Theoretical Concepts for Experimentation

Macrocognition - *Problem Space and Influence of Task*

Theoretical Issue – Problem Space and Task Complexity (Wood, 1986)

- Component Complexity
  - Amount of distinct acts associated with task and amount of cues/problem elements to be processed
- Coordinative Complexity
  - Degree to which task variables need to be integrated for successful task completion

Task Complexity		**Component Complexity**	
		Low	**High**
Coordinative Complexity	**Low**		
	High		

Theoretical Concepts for Experimentation

Macrocognition - *Problem Space and Influence of Task*

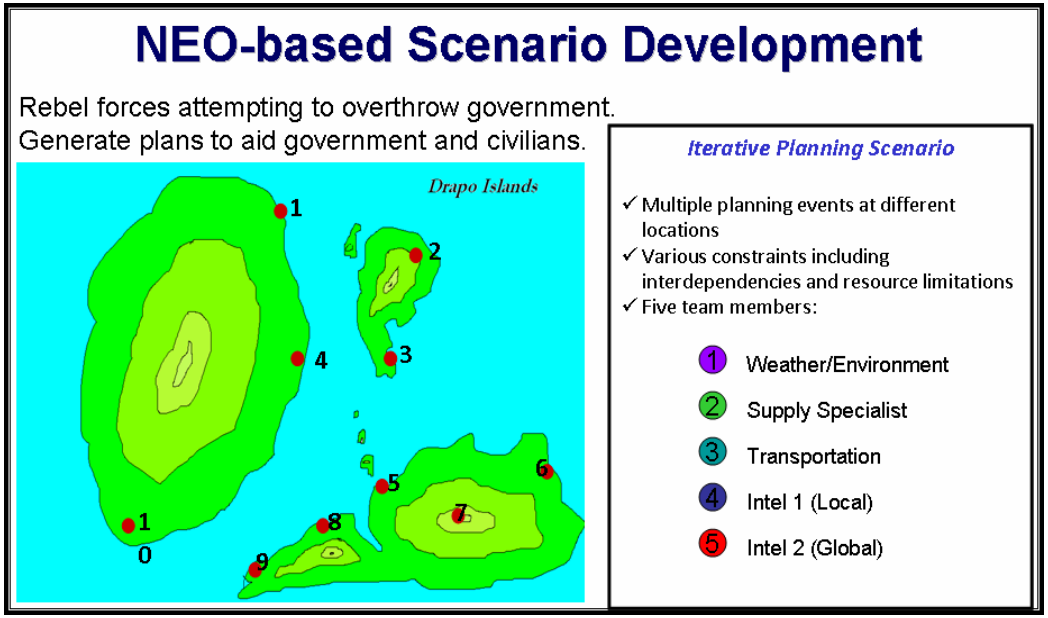
Theoretical Issue – Problem Space and Task Structure (Campbell, 1991)

- Determined by the number of task paths to follow and/or the amount of ambiguity or uncertainty associated with the paths.
  - Multiple Paths
    - Degree to which distinct outcomes are possible in task environment
  - Degrees of Uncertainty
    - Degree to which task alternatives are:
      - Ambiguous as to the path elements and/or
      - Differ in likelihood of occurring (i.e., amount of ambiguity associated with outcomes)

Task Structure		Multiple Paths	
		Low	High
Degree of Uncertainty	Low		
	High		

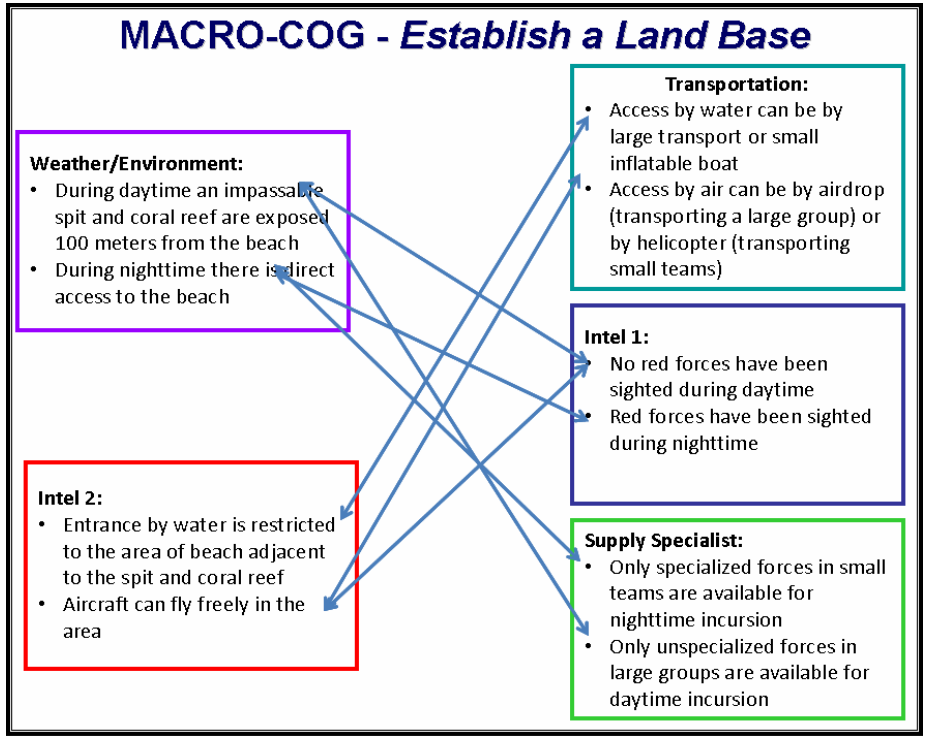
Theoretical Concepts for Experimentation

- **Task Complexity - *Component Complexity* in SUMMIT**
  - Amount of distinct acts associated with task and amount of cues/problem elements to be processed
  - MACRO-COG missions composed of several operations
    - Manipulating number of operations increases component complexity
      - For example, plans required for each operation - the more elements required in the plan the more complexity
    - Also number of resources, team members, and rules will be varied to manipulate component complexity



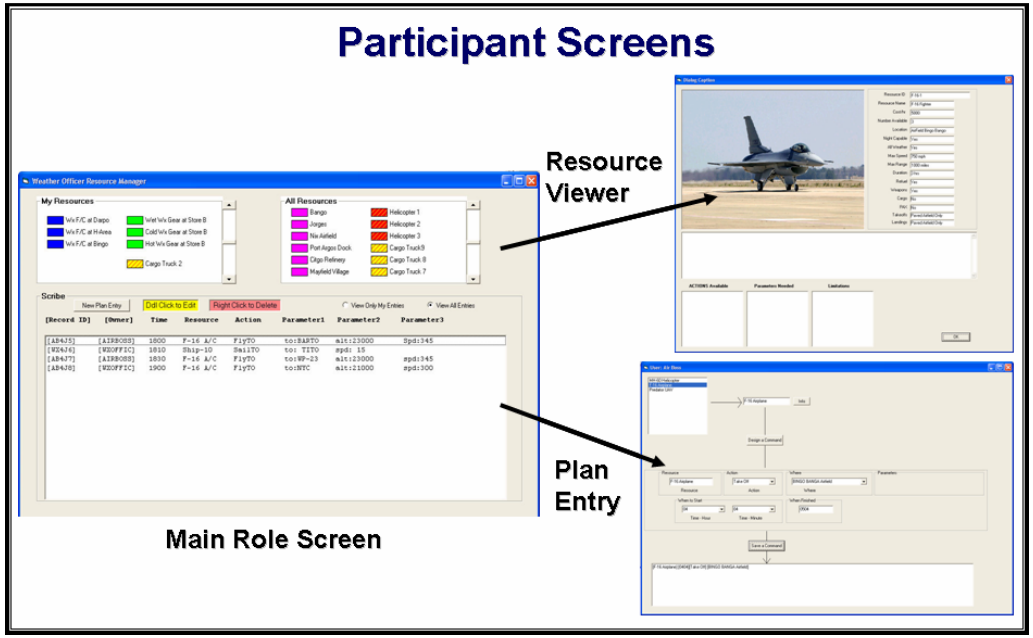
Theoretical Concepts for Experimentation

- **Task Complexity - *Coordinative Complexity* in SUMMIT**
  - Degree to which task variables need to be integrated for successful task completion
  - MACRO-COG allows for manipulating interdependencies between roles
    - For example, weather person knows critical for equipment person (who needs to decide if it is too windy to use a UAV for example)
  - *Scenario creation allows for determining amount of such interdependencies*



Theoretical Concepts for Experimentation

- **Task Structure - *Multiple Paths and Degree of Uncertainty* in SUMMIT**
  - MACRO-COG allows for manipulations of resources
    - Quantity and variety resources
      - Alter number of possible plans
      - Influence number of possible outcomes
    - Some resources are information resources
      - Each differing degrees of certainty (e.g., going to intel and weather roles)
      - Accessing information has different costs



Summary - Concepts for Experimentation

Experiment Thrust SUMMARY

- A) Overarching concepts for macrocognition experiments
  - How do task factors alter macrocognitive processes?
  - How does distributed interaction influence differing elements of collaboration?
  - What is the impact of agent-based team members?

- B) Metrics experimentation to support more diagnostic and construct valid understanding of macrocognition

Thank you

STRUCTURAL MODEL OF TEAM COLLABORATION

Problem Area Characteristics

Collaborative Situation Parameters:

- time pressure
- information/knowledge uncertainty
- dynamic information
- large amount of knowledge (cognitive overload)
- human-agent interface complexity

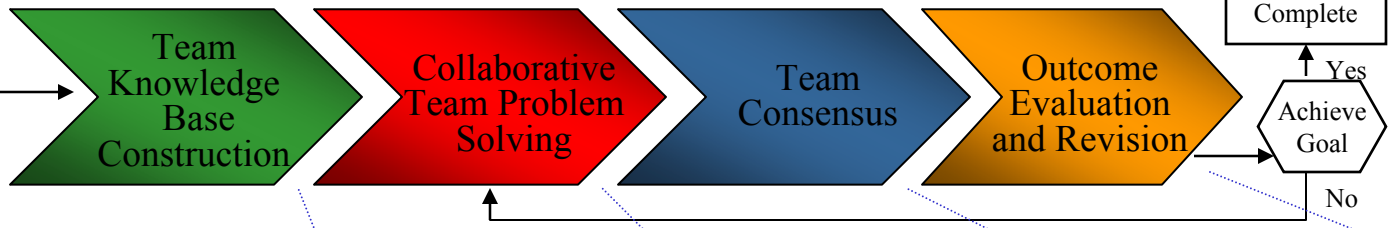
Team Types

- asynchronous
- distributed
- culturally diverse
- heterogeneous knowledge
- unique roles
- command structure (hierarchical vs. flat)
- rotating team members

Operational Tasks

- team decision making, COA selection
- develop shared understanding
- intelligence analysis (team data processing)

Collaboration Stages



Meta-Cognitive:

- individual understanding of problem conditions
- individual mental model development of situational significance
- goal development
- team mental model of problem
- team plan to solve problem
- track team's mental model changes
- understanding remaining items to resolve
- compare problem solution against goals

Information Processing:

- problem identification
- understanding problem task
- establish team communication and trust
- establish data filtering methods
- establish meaning transfer conventions
- goal definition
- iterative information collection & analysis
- develop, rationalize, & visualize solution alternatives
- team negotiation of solution alternatives
- analyze, revise output

Knowledge Building:

- problem definition
- individual task knowledge
- individual team knowledge
- team mental model of team
- team task knowledge
- domain expertise
- shared understanding
- collaborative knowledge
- collaborative knowledge
- shared understanding
- goal requirements
- exit criteria

Communication Mechanism for Information Processing and Knowledge Building (applies to all stages):

- presenting individual information
- disagreement
- questioning
- discussing individual information
- negotiating perspectives
- discussion of possible solutions
- discussing team generated information
- providing rationale for individual solutions
- agreement